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(54) Microwave oven

(57) A microwave oven comprises a heating chamber, detector means 43 for detecting infrared rays radiated from an object 41 heated in the heating chamber, chopper means 44 for periodically interrupting the path of the infrared rays to the detector means, an oscillator for producing an oscillating signal for driving the copper means, and means for regulating the phase of the output of the detector means relative to the phase of the oscillating signal to its optimum value.

The detector means does not require any manual adjustment of phase of which a deviation is caused by changes of power frequency, is a small and thin structure and is capable of detecting temperatures exactly with high reliability for a long period of time.

FIG.3

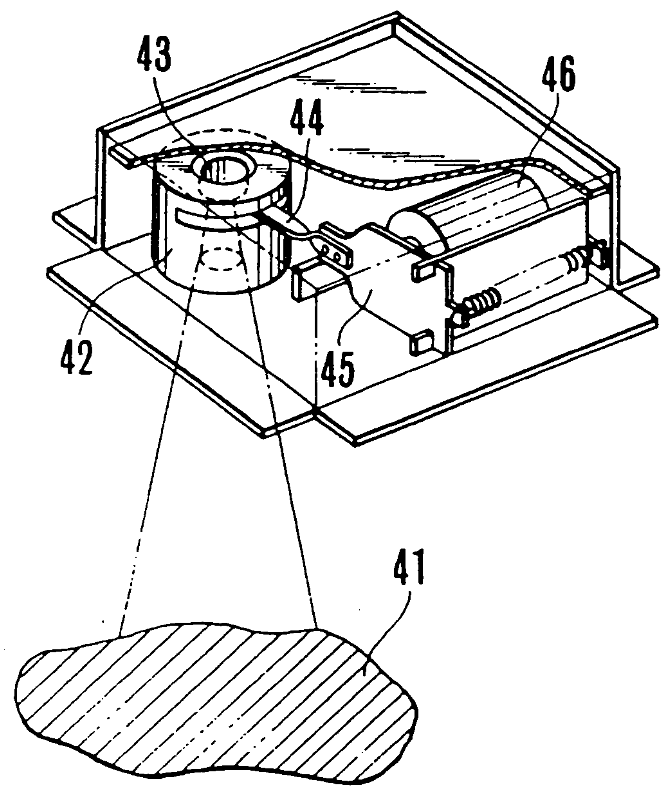

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FIG.1

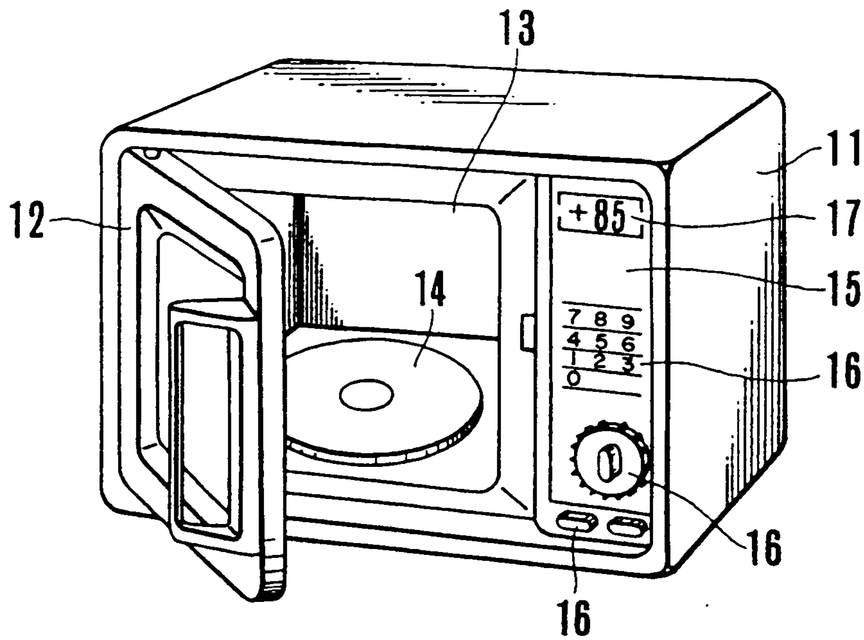


FIG.2

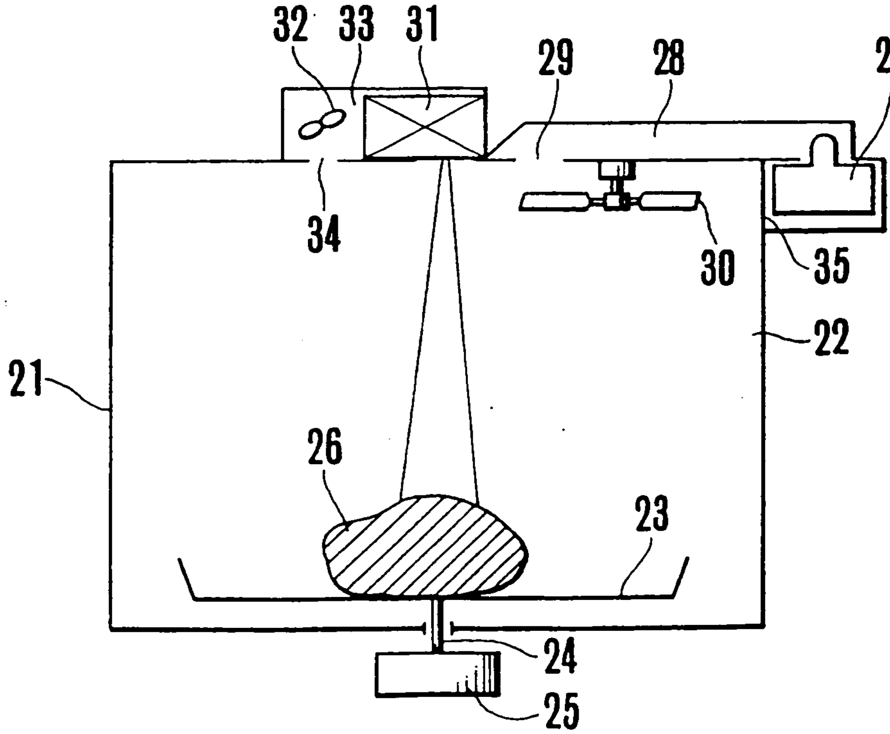


FIG.3

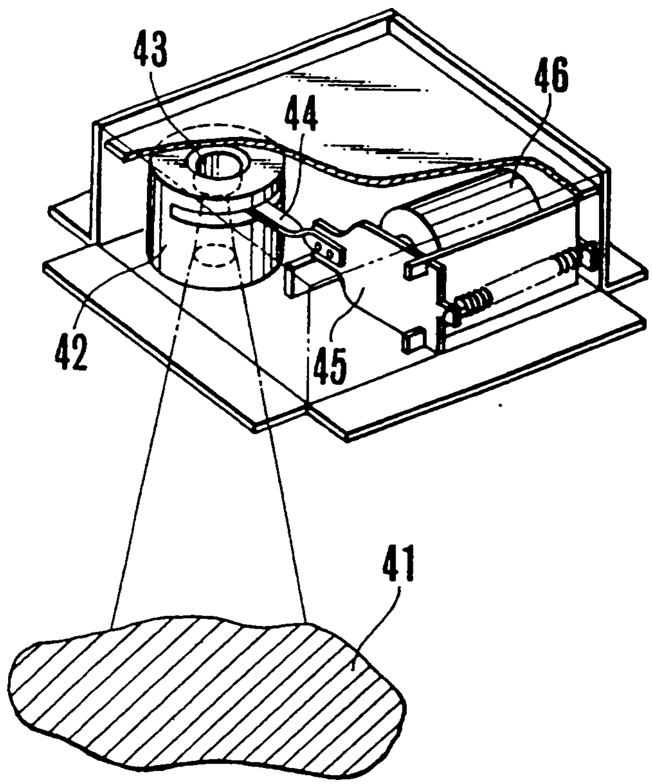


FIG.4

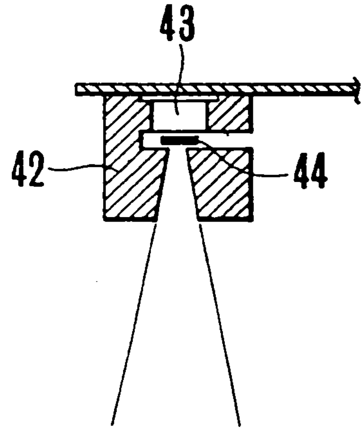
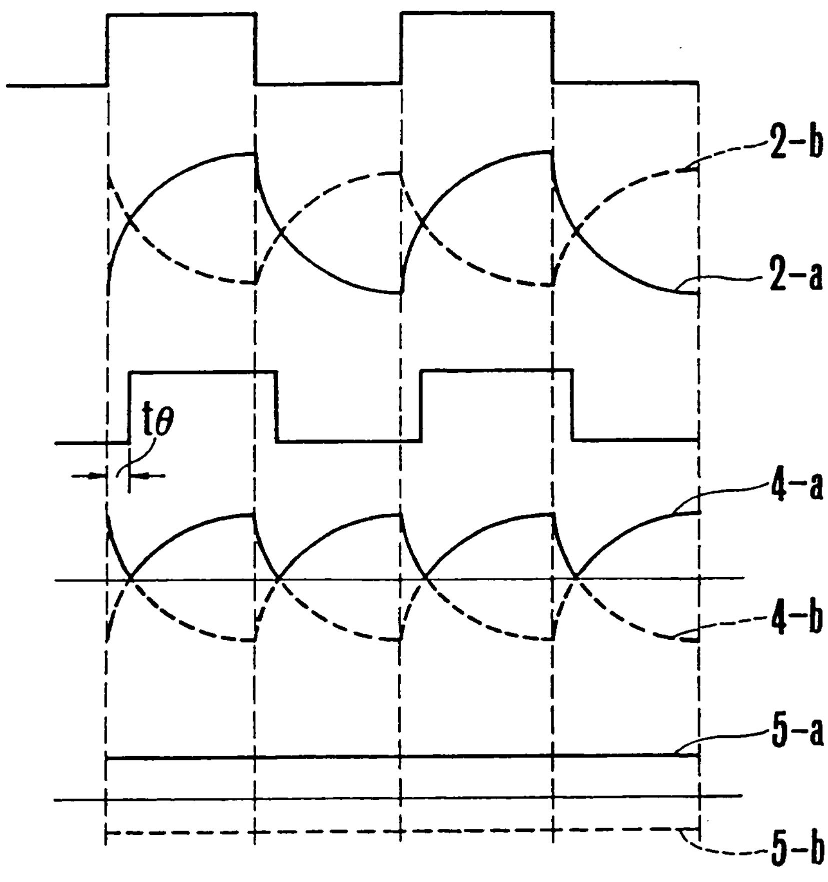


FIG.5



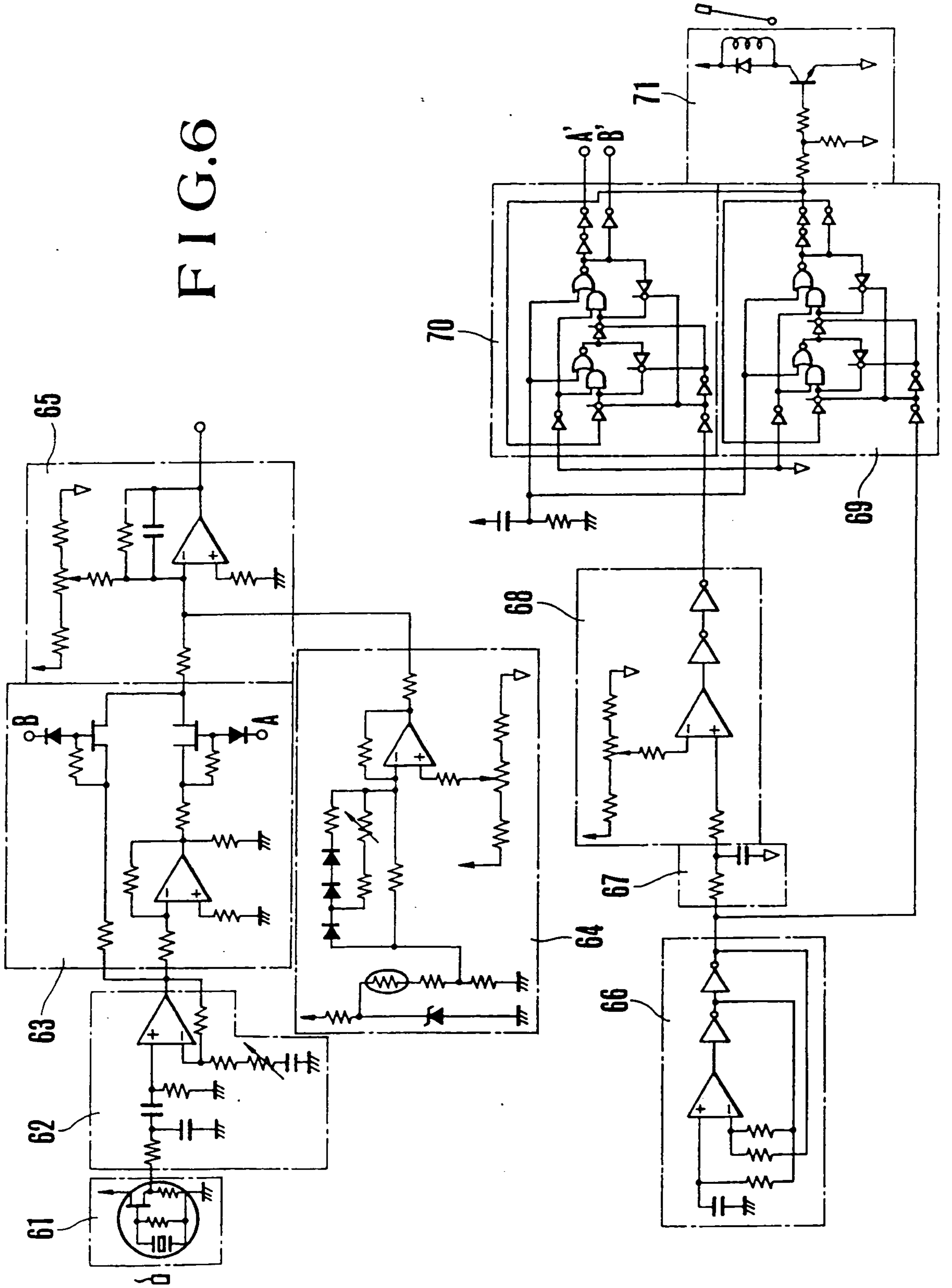
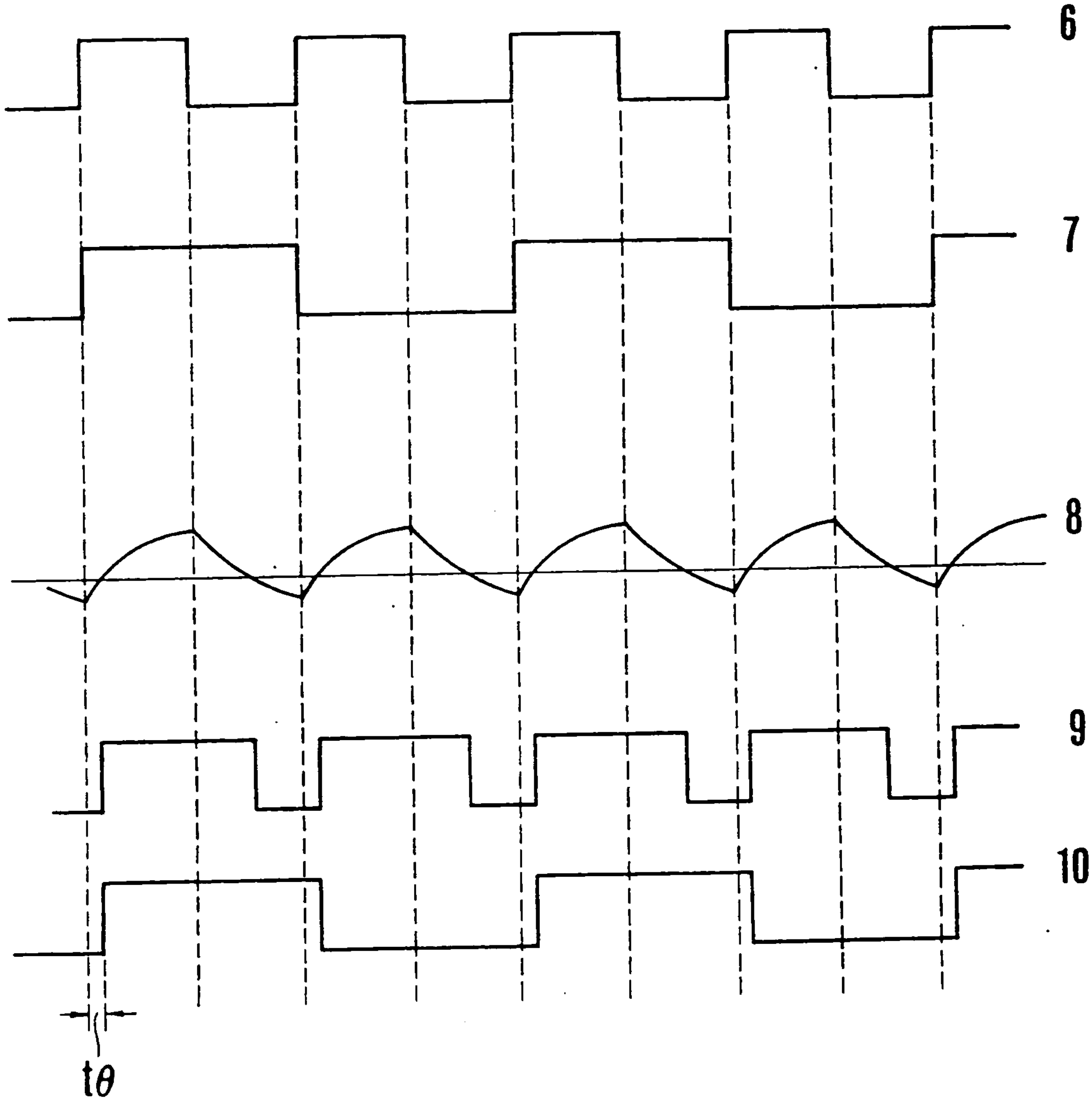
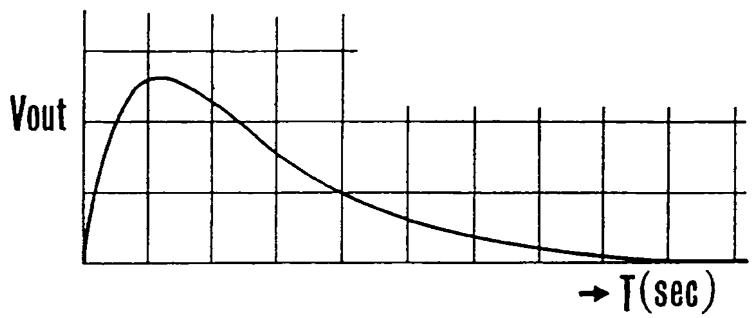


FIG.6

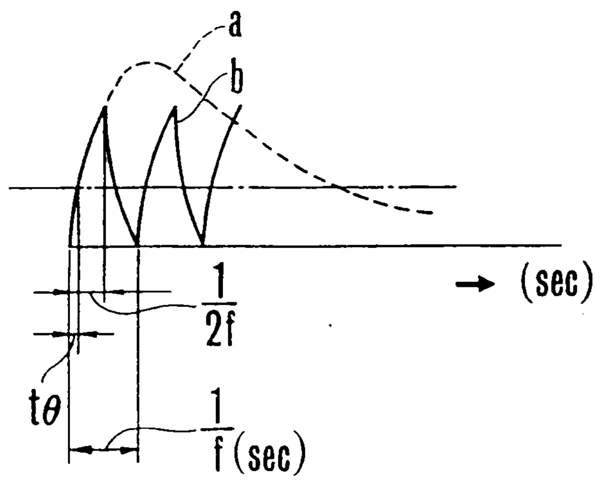
FIG.7



F I G.8



F I G.9



SPECIFICATION

Microwave oven

This invention relates to a microwave oven or range. More particularly, this invention relates to a microwave oven having an infrared detector which does not require any adjustment of the phase of which the deviation is caused by the fluctuations of power frequency, which is of a small and thin structure and which is capable of detecting the temperatures exactly with high reliability for a long period of time.

It is important to determine the exact temperature of an object to be heated for the purpose of operating a microwave oven effectively. For this purpose, there has been proposed a microwave oven incorporated with an infrared detector for detecting uncontactually the temperature of an object to be heated. In order to detect the temperature by using a pyroelectric infrared detector, it is required to alternately interrupt an incident infrared rays mechanically by a ray-chopper to get an alternating signal. This requires a mechanism for alternate driving of the chopper. For such alternate driving, a synchronous motor has been used because of its good stability, in rotational frequency and its inexpensiveness. Thus, there has been adopted a measure in which blades are mounted on the output shaft of such synchronous motor.

However, a synchronous motor has a drawback in that it has a smaller torque while it shows stable rotational frequency since it rotates synchronously with the power frequency.

In order to remove such a drawback, the synchronous motor is required to include a reduction gear or such a structure that the rotation of the blades and the motor shaft is started by a slippage upon start-up. However, such a motor as has a slippage structure shows a disadvantages in that it lacks reliability for a prolonged usage. The rotational number of a synchronous motor is different depending upon the power frequency, and a pyroelectric infrared detector has a frequency characteristic. Therefore, when a microwave oven is employed after removed to an area (locality) different in the power frequency, the sensitivity compensation is needed in respective areas. Further, in cases where the signals from the pyroelectric infrared detector are treated by synchronous detection, the blades of the chopper must be phased with the infrared input, namely, mechanical adjustment is required when the microwave oven is moved from one area to another where different power frequencies are used.

Finally, the aforementioned chopper-driving mechanism is structurally complicated due to unavoidable factors such as the size of the synchronous motor and others, leading to difficulty of reduction in size.

The present invention is to eliminate the above disadvantages. It is therefore an object of the present invention to provide a microwave oven having an infrared detector which will not be adversely affected by fluctuations in power frequency and which does not require any mechanical adjustment even at the time of adjustment operations.

Another object of the present invention is to provide a microwave oven having an infrared detector which is capable of being adjusted by a simplified electrical method and which is of a small and thin structure.

Further object of the present invention is to provide a microwave oven having an infrared detector which can carry out the exact detection of temperature of an object to be heated over a long period of time with high reliability.

Namely, a microwave oven of the present invention comprises a heat chamber, detector means for detecting infrared rays irradiated from an object to be heated in said heating chamber, chopper means for alternately interrupting the incidence of infrared rays to said detector means, an oscillator for oscillating a reference signal used for driving said chopper, and means for regulating the ouput of said detector means and the phase of said reference signal at their optimum conditions.

Figure 1 is a perspective view of the outline of a prior art microwave oven;

Figure 2 is a view showing the internal structure of a microwave oven;

Figure 3 is a perspective view showing the structure of an infrared detector which can suitably be used in the present invention;

Figure 4 is a sectional view illustrating the position of the chopper shown in Figure 3;

Figure 5 is a chart of timing between the infrared input and the ouput of the detector;

Figure 6 is a circuit diagram of an infrared detector;

Figure 7 is a chart of timing in a solenoid chopper;

Figure 8 is a chart relation of the output voltage with the unit input in a pyroelectric sensor; and

Figure 9 is a modification of Figure 8, in which the incident rays in Figure 8 has been chopped periodically.

Figure 1 is a perspective view showing the outline of a prior art microwave oven which includes a body 11. This body 11 includes an openable door 12 mounted on the forward portion thereof to form a heating chamber 13 which is defined by the door 12 and the inner walls of the body 11. The heating chamber 13 includes a rotary table 14 located above the bottom thereof and on which an object to be heated is placed. As is well known in the art, the object to be heated in the heating chamber 13 can be subjected to irradiation of electromagnetic wave (microwave), by the energy of which molecules of water in the object are excited to heat the object. The forward face of the microwave oven body 11 has a control panel 15 located adjacent to one side. The control panel 15 includes various operation switches 16 and an indicator 17. When the above operation switches 16 are selectively actuated, heating conditions can be set such as intensity of energy in an electromagnetic wave to be irradiated, time of irradiation and others. The indicator 17 displays the temperature of the object to be heated which has been detected by any suitable temperature detector

containd in the body 11.

Such a microwave oven has an internal construction as shown in Figure 2 in which a rotary table 23 is disposed within a heating chamber 22 of a microwave oven body 21. The rotary table 23 is operatively connected to the output shaft 24 of a motor 25 which extends through the bottom of the body 11 into the heating chamber 22. An object to be heated 26 is placed on the rotary table 23 and rotated therewith when the table 23 is rotated by the motor 25. The body 21 includes a magnetron 27 disposed in the upper section thereof which generates microwave energy. The microwave energy is introduced into the heating chamber 22 through a waveguide 28 to heat the object 26. A microwave agitating fan 30 is disposed adjacent to the opening 29 of the waveguide 28 and can be rotated by means of a flow of air to equalize the microwave energy in the heating chamber. The upper section of the body 21 also includes an infrared detector 31 for detecting infrared rays irradiated from the heated object 26. The infrared detector 31 is cooled by a flow of air which is introduced by a fan 32 through an air passage 33. This air flow is introduced into the heating chamber through an inlet of air 34 in the top wall of the heating chamber and then discharged through an outlet port 35 to atmosphere together with matters emitted from the heated object 26 such as steam and others.

The infrared detector 31 in such an arrangement may be of such a structure as shown in Figure 3 in accordance with the present invention.

Referring to Figure 3, infrared rays emitted from the surface of an object to be heated 41 are restricted by means of an optical diaphragm 42 before they are incident on a pyroelectric infrared detector 43. The infrared rays to the detector are alternately interrupted by means of a chopper 44 which is disposed adjacent to the detector, a moving part 45 which is disposed adjacent to said chopper, and a solenoid-driving part 46 which consists of an iron core, a coil, a solenoid and a spring.

Figure 4 is a sectional view illustrating the chopper 44 at a position in which it is located in close proximity to the detector 43 at the bottom of the optical diaphragm 42 having a frusto-conical opening. Thus, the chopper is positioned at such an area that the infrared rays to be incident on the detector are most restricted, resulting in improvement of function.

In the present invention, it is preferred that said chopper is in a position to interrupt infrared rays when it stops.

Figure 5 illustrates a relationship between a reference signal and the output of the detector. The infrared rays are inputted to the infrared detector in the form of a rectangular wave as shown by 1 while the detector generates at output a signal having a waveform as shown by 2. If the chopper blade has a temperature higher than that of an object to be heated, the output signal of the detector would have such a waveform as shown by 2a. If the temperature of the object to be heated is higher than that of the chopper blade, the output signal would be of such a waveform as shown by 2b. In order to obtain a signal synchronized with the infrared detector, therefore, the above signal 2 is inverted midway between the peaks and converted into a signal which is out of phase by t_θ as shown by 3. Thus, the phase relation between the reference signal which is the infrared input and the output of the detector can be maintained at an optimum condition. Numeral 4 designates the waveform of a signal which is obtained by processing the signal 2 under synchronous detection in the same manner as described hereinbefore. It is convenient that the signal 4 is finally used in the form of direct currents as shown by 5.

Figure 6 shows an example of such a signal processing circuit which will not be described in detail. A signal is supplied from a pyroelectric infrared detector 61 to a filter and AC amplifier 62, a synchronous detector 63, a detecting circuit of chopper blade temperature 64, and outputting circuit of temperature signal 65 for adding and smoothing these signals, in such an order as described. And, the output of an oscillator 66 is coupled with an integrator 67, a comparator 68 and a flip flop circuit 69 to actuate a solenoid 71. Reference numeral 70 denotes a flip flop circuit causing the synchronous detector to switch. The above relationship between the components will be described with reference to Figure 7. The output 6 of the oscillator 66 is converted into a waveform as shown by 7 by means of a D-type flip flop circuit 69 and then added into a solenoid chopper. In the illustrated position, the infrared input is alternately interrupted. The output of the oscillator 66 also is supplied to the integrator 67 wherein it is converted into a waveform as shown by 8. By varying the comparison voltage in the comparator, there is obtained a signal 9 which is out of timing relative to the output waveform 6. This signal 9 is supplied to the D-type flip flop circuit 70 wherein it is binary divided down to form a synchronized signal 10. This signal 10 is out of phase by t_θ in synchronism with the solenoic driving signal 7. This means that there has been electrically adjusted the phase angle t_θ which had been obtained by mechanically centering the signal detected by the infrared input described and the chopper blade as explained in Figure 5.

In the present invention, the phase angle t_θ of the output of the detector means and the reference signal of the oscillator at their optimum conditions is as follows. Namely, in cases where the infrared detector is drived, for example, at a frequency of f Hz using an element having a thermal time constant τ_T and an electric time constant τ_E, there has been known that the output voltage (i.e., one step response) to the unit input of the pyroelectric type sensor can be obtained from the following equation:

$$V(t) = \frac{\varepsilon AR}{G} \cdot \frac{{}^{\alpha}PS}{\alpha T} \cdot \frac{1}{1/\tau_E - 1/\tau_T} \{ \exp(-\frac{t}{\tau_T}) - \exp(-\frac{t}{\tau_E}) \}$$

Upon calculation of

$$V'(t) = \exp\left(-\frac{t}{\tau_T}\right) - \exp\left(-\frac{t}{\tau_E}\right)$$

assuming that τ_T and τ_E are 0.25 and 0.1, respectively, Figure 8 is obtained.

If the incident rays are chopped periodically, Figure 9 is obtained. In Figure 9, small a shows one step response and small b shows response at the time of repeated incidencies.

The delayed angle at t_θ may be obtained by obtaining the center of the peak from a half value of V' (t) at $\frac{1}{2f}$ (sec), obtaining then t_θ from the so obtained center of peak and assuming that $\frac{1}{2f}$ is $\frac{\pi}{2}$.

Upon calculation, it is about 27°, and upon experiment, it is 36°.

Difference between these values is considered to have been caused by an measurement error of τ_E and τ_T. Accordingly, the values obtained actually by experiments have been adopted here.

It will be apparent from the foregoing explanation that the microwave oven according to present invention does not require any mechanical adjustment in cases when the oven is used after moved to an area where different power frequency is employed. Further, it does not cause such problems as locking phenomenon and back rotation due to smaller torque of the motor, because the infrared detector is drived by a solenoid. In addition, the oven of the present invention has an advantages in that it requires no device for detecting the rotation of the chopper blade and that it is possible to make its structure to be of simplified small and thin structure.

CLAIMS

1. A microwave oven characterized by a heat chamber, detector means for detecting infrared rays irradiated from an object to be heated in said heating chamber, chopper means for alternately interrupting the incidence of infrared rays to said detector means, an oscillator for oscillating a reference signal used for driving said chopper, and means for regulating the output of said detector means and the phase of said reference signal at their optimum conditions.
2. A microwave oven according to Claim 1, wherein said chopper is located in an area in which the infrared rays to said detector means is most restricted.
3. A microwave oven according to Claim 1 or 2, wherein said chopper is a solenoid chopper.
4. A microwave oven according to Claim 1, wherein the means for regulating an output of said detector means and a phase of said reference signal at their optimum conditions are consisting of an oscillator for driving the chopper and a phase shifter for generating a switching of timing for synchronous detection of an output of the sensor.
5. A microwave oven substantially as described herein with reference to Figures 3 to 9 of the accompanying drawings.

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